

# *Salvelinus fontinalis* (Mitchill, 1814) (Salmoniformes: Salmonidae): The Presence of Brook Trout in Peru

Eduardo Oyague-Passuni<sup>1,3\*</sup> and Pablo J. Franco<sup>2</sup>

1 Knight Piésold Consultores S.A., Departamento de Medio Ambiente, Calle Aricota 106, Piso 5. Santiago de Surco, Lima, Perú.

2 Universidad Nacional Jorge Basadre Grohmann, Departamento de Biología, Ciudad Universitaria, Calle Miraflores s/n. Tacna, Tacna, Perú.

3 CORBIDI, División de Vida Acuática/Limnología, Calle Santa Rita 105, Dpto. 202. Santiago de Surco, Lima, Perú.

\* Corresponding author. E-mail: [eyague@knightpiesold.com](mailto:eyague@knightpiesold.com)

**ABSTRACT:** Salmonidae were introduced in the Peruvian freshwaters during the first quarter of the 20<sup>th</sup> century with the Rainbow Trout, *Oncorhynchus mykiss* (Walbaum, 1792), and later with three more species: *Salmo trutta* Linnaeus, 1758, *Salvelinus namaycush* (Walbaum, 1792) and *Salvelinus fontinalis* (Mitchill, 1814). Only *Oncorhynchus mykiss* seems to have established itself extensively and successfully, is regularly reported and appears on the taxonomic checklists. This article reports on the presence of *Salvelinus fontinalis* in the high Andes of southern Peru, an area which is biogeographically associated with the Lake Titicaca Plateau.

The introduction of inland water fish species to Peru follows attempts to develop production activities like aquaculture, breeding and trading of ornamental fish and sport fishing. To date, the presence of 20 non-native inland water species in Peru has been reported (Ortega *et al.* 2007). The first introduced species known was the Rainbow Trout, which was introduced in 1927, in the Province of Yauli, Region of Junín. The first important seedlings of this species took place in Lake Titicaca between 1939 and 1941, and at present its distribution range at national level covers almost all of the watersheds, including an Andean sector with an altitude exceeding 1500 m.a.s.l. (Ortega and Hidalgo 2008).

According to Welcomme (1988), apart from the Rainbow Trout, three more Salmonid species were introduced in Peru in the previous century: the Common European Trout, *Salmo trutta* Linnaeus, 1758, in 1928 and 1939, the Lake Trout, *Salvelinus namaycush* (Walbaum, 1792) in 1940 and the Brook Trout *Salvelinus fontinalis* (Mitchill, 1814) in 1955. In a review for the Symposium on Aquaculture in Latin American organized in 1974 by the Food and Agriculture Organization (FAO) of the United Nations, and in a publication three years later in the FAO Fisheries Reports, Vera and Berger (1977) quote the presence of three Salmonid species: the Rainbow Trout *Oncorhynchus mykiss* (Walbaum, 1792), the Common European Trout *Salmo trutta* Linnaeus, 1758, and the Brook Trout *Salvelinus fontinalis* (Mitchill, 1814). They mention successful establishment and a broad range of distribution at national level for all of these species. However, none of the two *Salvelinus* species, or *Salmo trutta*, appears on the Checklists of the Freshwater Fishes of Peru (Ortega and Vari 1986, Chang and Ortega 1995, Ortega *et al.* 2011), or in a recent review regarding the introduction of non-native fishes into Peruvian inland waters (Ortega *et al.* 2007) and they are nonexistent in the recent reports of environmental assessments performed in different areas of the Peruvian Andes.

Loubens (1989) points out that, apparently, spreading of *Salvelinus* spp. in Lake Titicaca was poor and unsuccessful and although the *Salmo trutta* could be registered in the Ilave River up to 1970, for 1988 only the presence of the Rainbow Trout was reported for the lake and its endorheic basin. In an article on freshwater fish of the Altiplano, a plateau between the Eastern and Western Andean mountain ranges, where Lake Titicaca is located, Vila *et al.* (2007) report that the Salmonid species introduced to the region included *Salmo trutta*, *Salvelinus fontinalis* and *Salvelinus namaycush*, however according to the authors none of these three species has been recorded recently.

In research carried out between October 2009 and April 2010 as part of the doctoral thesis of one of the authors of this article (PF), 25 *Salvelinus fontinalis* (Mitchill, 1814) specimens were collected in different stages of development in the village of Huaytire at 4500 m.a.s.l. in the District of Candarave, Province of Candarave, Region of Tacna, about 90 km from the Bolivian border to the southeast and 100 km from the border with Chile to the south (Figure 1). Biogeographically, according to the classification by TNC (Abell *et al.* 2008), this part of the Peruvian territory is located in the freshwater ecoregion of the Central Andean Pacific Slopes, and in the terrestrial ecoregion called Central Andean Puna, according to the categorization by WWF (Olson *et al.* 2001). Geographically and environmentally, both are located very close to the endorheic basin of Lake Titicaca. The Brook Trout specimens were caught in the Huaytire River, a small stream located approximately 3 km north of the village of Huaytire (Reference Coordinates: 70°20'12.81"W, 16°50'5.15"S). This water body is part of a small endorheic basin that drains into the Suches Lagoon. It crosses a wetland system (high Andean bogs) before it reaches the river mouth.

All individuals considered for this paper were identified by evaluating and comparing their morphological features with the features described by Page and Burr (1991). Four

TABLE 1. Visual attributes of Rainbow and Brook Trout compared from existing specimens in CORBIDI Freshwater Fishes Collection.

Characteristics	Brook Trout ( <i>Salvelinus fontinalis</i> )	Rainbow Trout ( <i>Oncorhynchus mykiss</i> )
Vermiculations	Present	Absent
Spots	Small red spots	Black spots
Lateral stripe	Absent	Pink or Reddish
Specimens compared	CPC-2010-128, CPC-2010-129, CPC-2010-130, CPC-2010-131	CPC-2010-028, CPC-2011-071 CPC-2011-072

specimens were deposited in the CORBIDI Freshwater Fishes Collection within the following codes: CPC-2010-128, CPC-2010-129, CPC-2010-130 and CPC-2010-131, these four individuals were compared by its characteristic attributes with specimens of Rainbow Trout present in the Collection (CPC-2010-028, CPC-2011-071 and CPC-2011-072); any visual differences are summarized in the Table 1.

For all the specimens collected the following morphometric values were recorded in the field: Total Length, Fork Length, Standard Length, Head Length (all in millimeters) and Weight in grams. Part of this information (TL and W) was used to estimate the condition factor of the specimens studied (Table 2). Based on the morphometric data obtained, the color patterns and other external features described by Hazzard (1932) and Crisp (2000), it was determined that most of the collected specimens were in an early stage of development (84%), and only four of them were adults. According to the values estimated for the Fulton’s condition factor (Nash *et al.* 2006), all individuals captured showed appropriate development conditions with an optimal allometric length/weight relationship for individuals developing in the wild (Murphy and Willis 1996), which indicates an adequate supply of resources.

The presence of *Salvelinus fontinalis* in the southern part of the Peruvian Andes is undeniable, and the species – as suggested by Vila *et al.* (2007) – is possibly distributed throughout the region adjacent to the endorheic basin of Lake Titicaca. According to historical information, *Salvelinus fontinalis* (among other Salmonid species) was introduced to the region, and its current presence corresponds to isolated populations with few individuals due to its low quality as a focal species for Aquaculture Programs (compared to the Rainbow Trout) and the high fishing pressure experienced by Salmonids in the lotic environments of the high Andes.

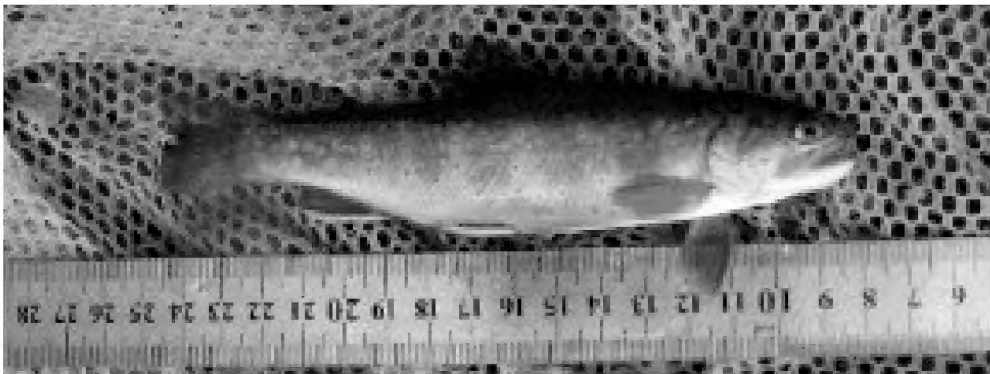


FIGURE 2. One specimen of *Salvelinus fontinalis* (Mitchill, 1814), captured in Huaytire river.

TABLE 2. Morphometrics and Life Cycle Stages of 25 Brook Trout from the Huaytire River. **TL**: Total Length (in mm); **FL**: Fork Length (in mm); **SL**: Standard Length (in mm); **HL**: Head Length (all in mm); **W**: Weight (in grams); **K**: Fulton’s Condition Factor; **LC**: Life Cycle Stage; **A**: Adult; **J**: Juvenile; **P**: Parr; **CPC**: CORBIDI Freshwater Fishes Collection (CORBIDI Peces Continentales-Year-Number)

Spec	TL	FL	SL	HL	W	K	LC	CPC
1	217.35	213.40	173.90	66.15	102.70	1.06	A	
2	191.09	181.45	163.93	62.64	63.30	0.91	A	2010-128
3	190.80	166.25	165.85	59.40	56.10	0.81	A	2010-129
4	156.24	149.96	141.62	51.51	41.50	1.09	A	
5	135.34	131.04	105.80	38.95	19.76	0.80	J	
6	122.00	113.28	107.06	39.80	14.74	0.81	J	
7	121.44	118.11	108.10	39.90	17.83	1.00	J	
8	112.35	102.00	85.56	35.64	11.32	0.80	J	2010-130
9	111.55	105.45	98.98	37.37	12.35	0.89	J	
10	111.30	102.00	93.45	33.92	10.19	0.74	J	
11	106.70	109.18	99.75	34.30	12.94	1.07	J	
12	100.98	97.65	81.60	31.62	7.96	0.77	J	
13	92.92	96.03	92.40	31.04	8.14	1.01	J	
14	89.28	92.07	82.00	31.03	7.46	1.05	J	
15	85.14	75.44	69.00	26.73	4.98	0.81	J	
16	79.68	79.20	70.08	24.96	5.86	1.16	J	
17	67.32	61.38	59.36	20.16	3.37	1.10	P	
18	64.89	57.00	51.70	20.20	2.56	0.94	J	
19	62.22	61.36	53.56	19.76	2.44	1.01	P	
20	58.80	54.15	52.02	18.62	2.18	1.07	P	
21	56.40	57.57	55.12	18.43	2.37	1.32	P	2010-131
22	54.06	55.08	47.00	15.81	1.53	0.97	P	
23	52.38	50.44	47.84	17.00	1.17	0.81	P	
24	51.52	49.68	48.51	15.81	1.32	0.97	P	
25	50.22	53.56	50.40	16.83	1.52	1.20	P	

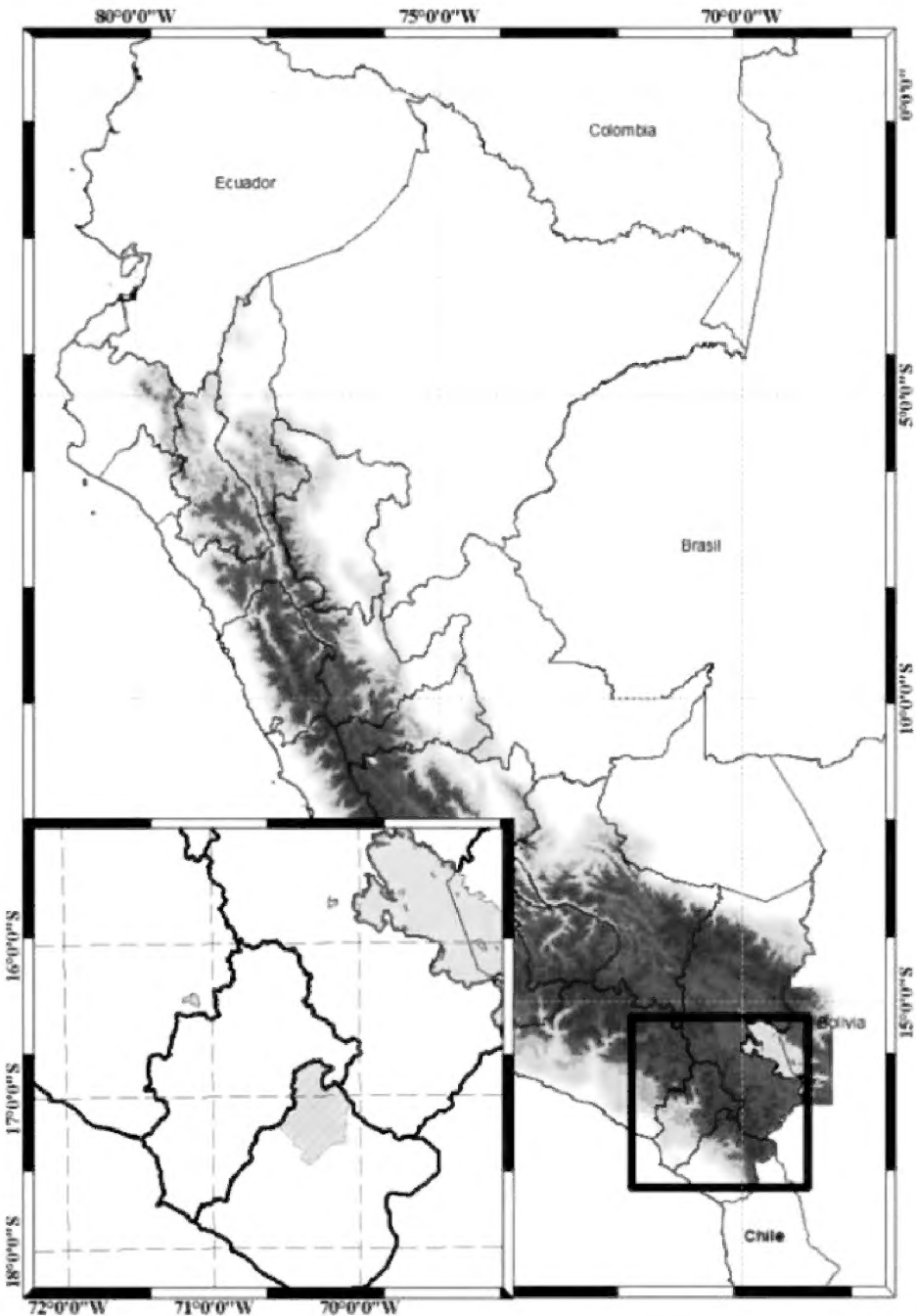


FIGURE 1. Study Area (Candarave Province in Southern Peru).

**ACKNOWLEDGMENTS:** To our friends Mario Cajacuri Suárez, Adrián Vera and Edgardo Enríquez for their help with the collection of biological material, the revision of the original text and for the suggestions made during the development of the study

#### LITERATURE CITED

- Abell, R., M.L. Thieme, C. Revenga, M. Bryer, M. Kottelat, N. Bogutskaya, B. Coad, N. Mandrack, S. Contreras-Balderas, W. Bussing, M.L.J. Stiassny, P. Skelton, G.R. Allen, P. Unmack, A. Naseka, R. Ng, N. Sindorf, J. Robertson, E. Armijo, J.V. Higgins, T.J. Heibel, E. Wikramanayake, D. Olson, H.L. López, R.E. Reis, J.G. Lundberg, M.H. Sabaj-Pérez and P. Petry. 2008. Freshwater Ecoregions of the World: A New Map of Biogeographic Units for Freshwater Biodiversity Conservation. *BioScience* 58(5): 403-414.
- Chang, F. and H. Ortega. 1995. Additions and Corrections to the List of Freshwater Fishes of Peru. *Publications of the Natural History Museum* 50(1): 1-12.
- Crisp, D.T. 2000. *Trout & Salmon: Ecology, Conservation and Rehabilitation*. Oxford: Blackwell Science. 209 p.
- Hazzard, A. S. 1932. Some Phases of the Life History of the Eastern Brook Trout, *Salvelinus fontinalis* Mitchell. *Transactions of the American Fisheries Society* 62(1): 344-350.
- Loubens, G. 1989. Observations sur les poissons de la partie bolivienne du lac Titicaca. IV *Orestias* spp., *Salmo gairdneri* et problèmes d'aménagement. *Revue d'Hydrobiologie Tropicale* 22 (2): 157-177.
- Murphy, B. R. and D. W. Willis. 1996. *Fisheries Techniques*. Bethesda: American Fisheries Society. 732 p.
- Nash, R. D. M., A. H. Valencia and A. J. Geffen. 2006. The Origin of Fulton's Condition Factor-Setting the Record Straight. *Fisheries* 31(5): 236-238.
- Olson, D., E. Dinerstein, E. Wikramanayake, N. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D'Amico, I. Itoua, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Aallnut, T.H. Ricketts, Y. Kura, J.F. Lamoreaux, W.W. Wettengel, P. Hedao and K.R. Kassem. 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth. *BioScience* 51(11): 933-938.
- Ortega, H. and R. P. Vari. 1986. Annotated Checklist of the Freshwater Fishes of Peru. *Smithsonian Contributions to Zoology* 437(1): 1-25.
- Ortega, H., H. Guerra and R. Ramírez. 2007. The Introduction of Nonnative Fishes into Freshwater Systems of Peru; p. 247-278 In T.M. Bert (ed.). *Ecological and Genetic Implications of Aquaculture Activities*. Dordrecht: Springer.
- Ortega, H. and M. Hidalgo. 2008. Freshwater fishes and aquatic habitats in Peru: Current knowledge and conservation. *Aquatic Ecosystem Health & Management* 11(3): 257-271.
- Ortega, H., M. Hidalgo, E. Correa, J. Espino, L. Chocano, G. Trevejo, V. Meza, A. M. Cortijo and R. Quispe. 2011. *Lista anotada de los peces de aguas continentales del Perú: Estado actual del conocimiento, distribución, usos y aspectos de conservación*. Lima: Ministry of the Environment, General Bureau of Biological Diversity – National History Museum, National University of San Marcos (UNMSM). 48 p.
- Page, L. M. and B. M. Burr. 1991. *A Field Guide to Freshwater Fishes: North America North of Mexico*. Boston: Houghton Mifflin Co. 432 p.
- Vera, J. and C. Berger. 1977. Introducción y transplante de peces y crustáceos en el Perú. *FAO Fisheries Report* 159(1): 305-312.
- Vila, I., R. Pardo and S. Scott, 2007: Freshwater fishes of the Altiplano. *Aquatic Ecosystem Health & Management* 10(2): 201-211.
- Welcomme, R.L., 1988: International introductions of inland aquatic species. *FAO Fisheries Technical Paper* 294(1): 1-318.

RECEIVED: June 2012

ACCEPTED: May 2013

PUBLISHED ONLINE: August 2013

EDITORIAL RESPONSIBILITY: Rubens Pazza